

An Object-Oriented Tool for the Generation and Management of Multimedia Patient Folders

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ABSTRACT

Computer-based patient folders are evolving from the simple reproduction of traditional paper documents toward active tools, able to support the whole diagnostic and therapeutic process. The advent of multimedia has given emphasis to the idea of computerized folder, i.e. a collection of heterogeneous kinds of documents pertaining different media.

In this paper we present a tool implementing generation and management of multimedia patient folders showing its architecture and functionalities and the innovative interaction paradigms adopted. The tool realized allows medical users to choose the concepts desired in their target application and generates a customized patient folder management system by means of a friendly interface and without the need of a programming language. The system automatically created can be effectively employed for reporting and storing clinical cases.

1. INTRODUCTION

The patient folder is the essential support for documenting the process of care, but also for assisting ward management, filing and evaluation of health-care quality.

If we review the computer applications realized so far, it is clear that there is no model sharable by everyone. HL7 addresses the problem of structuring the electronic data exchange in healthcare environments [1], whereas in Europe standardization activity is carried on by the CEN with respect to the structure of the electronic patient record [2].

Each application implemented so far is optimized with respect to the peculiar function to be performed (e.g.: clinical support, data interchange, statistical analysis, legal documentation). Such heterogeneity reflects the different perspectives of the users and the quest for commonalities would be useless. Anyhow, an emerging trend during the years is the transition from passive documentation to active support. Among the most relevant achievements we may quote: the

"Problem Oriented Medical Record", [3], the "Decision Directed Medical Record" [4] and more recently "PEN&PAD" [5].

Computer-based patient folders are less and less a mere reproduction of the traditional paper documents. The advent of multimedia has especially fostered their evolution toward an active tool, able to sustain the whole diagnostic and therapeutic process. From the concept of *medical record* as a structured set of information, emphasis has been given to the idea of *folder*, i.e. a collection of heterogeneous kinds of documents pertaining different media.

The question is no longer the definition of the model best fitting the physician's requirements, but the creation of a folder that from clinical requirements is able to adapt the information layout, namely which information has to be managed and in which way it must be shown.

In this paper we present a tool implementing generation and management of multimedia patient folders. In the next paragraph its architecture is sketched out, whereas the third one illustrates the innovative user-interaction paradigms adopted.

2. THE OBJECT-ORIENTED DESIGN AND THE ARCHITECTURE OF THE SYSTEM

Physicians usually do not share the same concepts in managing information about their patients. It is expected that every patient folder management system will include slots for personal data, main symptoms and diagnostic images. In addition, some physician might consider familiar anamnesis, others would like to see the staging of a disease and so on.

The tool described in this paragraph allows medical users to choose the concepts to be present in their target application starting from scratch or from a default configuration. It generates a customized patient folder management system by means of a friendly interface and without employing a programming language. The system automatically created can be effectively used for reporting and storing clinical cases. It will be always possible to modify its structure according to future requirements.

The tool supports multimedia, managing texts and images in an integrated way. The impact that such an

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integration may achieve on the users is not to be stressed here. We plan to incorporate bio-signals and voice annotation in future releases.

The tool runs on Macintosh platform and has been developed using the Prograph® programming environment. A case-study has been carried out and resulted in the definition of a multimedia patient folder used experimentally by the 4th Surgical Clinic of the University Hospital of Rome. Since this project is carried on under a European Union funded initiative, English is the language adopted for the interface which must be shared and validated by the other partners. However, clinical data of the case-study are directly entered in Italian.

The overall architecture of the system is composed by the following five modules [6]:

- a) patient folder designer
- b) multimedia patient folder manager
- c) presentation manager
- d) user interface
- e) user models manager

a) patient folder designer

Physicians use this module to define the structure of the folder. They choose the concepts relevant for their clinical purposes which will be included in the target application. This activity generates an object-oriented model of medical concepts, where the classic relationships hold: generalization (IS_A) and aggregation (PART_OF). Therefore different levels of abstractions may be defined and each concept may be broken down into more elementary concepts and vice-versa.

The taxonomy of concepts created by means of this model is isomorphic to the logical organization of data in the folder. Figure 1 reports a fragment of such an organization, as it might have been defined by a physician.

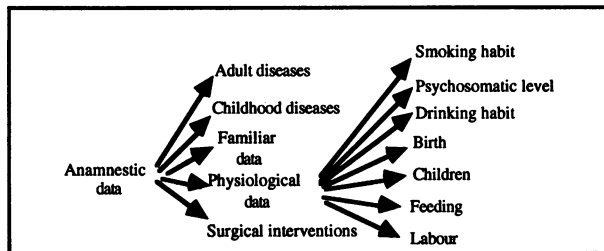


Figure 1

A fragment of a possible taxonomy of concepts

In this way it is possible to say that Adult diseases, Childhood diseases, Family data, Physiological data and Surgical interventions are not only Anamnestic data but also the concepts which in the patient folder constitute the anamnestic data. Likewise, Smoking

habit, Psychosomatic level, Drinking habit, Birth, Children, Feeding and Labour are Physiological data.

Depending on his/her own particular specialization, a physician can organize the medical folder to suit himself/herself. Every physician is free to add or delete an exam and re-arrange the corresponding taxonomy of concepts in order to conform to his/her requirements.

Figure 2 shows the interface of the designer which manages these concepts. In the example shown "rectosigmoidoscopy" is being added and will be a slot in the patient folder that the tool is going to define. The picture shows also the features to be chosen for "rectosigmoidoscopy". In this case data type is "hypermedia", this means that the system will allow links between sentences and details of an image. The "Time dimension" window accounts for the temporal phases which are clinically relevant for the entities [6]. In this case all the phases make sense and the user enables them by clicking on the corresponding boxes.

b) multimedia patient folder manager

This module retrieves and stores the information that constitute the contents of the medical folders by means of a relational DBMS which is able to handle images and texts in an integrated way.

c) presentation manager

The presentation manager is the kernel of the system. It determines the access to the patient folder data by processing the users' queries (handled by the user interface module). According to the user profile, it also select which information the interface has to show and in which way.

d) user interface

The human-computer interaction is managed by this module. It follows the requirements reported in the user models manager which are processed by the presentation manager. The system is able to create runtime the windows needed to show the user's required information. Object-oriented design allows to encapsulate behavioral features into classes of objects and to propagate them by means of the inheritance mechanism (e.g.: from "endoscopic exam" to "duodenoscopy"). This capability is exploited in the interface management, with respect to data presentation and manipulation requirements (see §3).

e) user models manager

The acquisition and storage of user models is achieved by means of this module. The user model formalizes the knowledge needed to implement the interaction between the physician and the system. It stores assumptions on those user aspects relevant to the system's behavior in the interaction session.

3. THE INTERACTION PARADIGMS

The dynamic management of the interface is a peculiar feature of this tool. During the consultation phase of the patient folder the user may escape from the rigid structure given to the information in the designing phase. In this case the system sets up dynamically new clinical data views.

The patient folder management system is able to adopt three different interaction styles in presenting the information.

The *default presentation* provides a layout which replicates exactly the structure given to the patient folder in the designing phase. A traditional interaction is carried on, by means of an interface completely pre-defined which remains stable during the consultation.

The *selective presentation* leaves the user free to pick up the data to be shown on the monitor. Whereas in the previous interaction style, once a class of information is chosen (e.g. "anamnesis"), it must be fully visualized, here the user browses an index of information items (e.g. a list of laboratory exams) and selects among them the most relevant ones.

The *co-operative interaction* relies on the user model. Here the system has an active role and determines its behavior also without the explicit control of the user. In fact it can show not only the data selected, but also other related facts on the patient, if reported (e.g. data on the same apparatus) [7].

Figure 3 shows an example of a window dynamically defined by the system. It arranges semantically related information, allowing for hypermedia links between sentences and details of images. Multimedia features are exploited, by showing the "miniature" of a diagnostic image which, of course, can be fully visualized in a high resolution monitor (the concept of "miniature" in multimedia system has been introduced by Christodoulakis in 1986 [8]).

The system employs the following criteria to arrange the information to be shown to the user:

- *Consistency of visual organization with temporal organization.*

If a patient has been submitted to a certain exam more than once, the different instances of this exam must be shown according to their temporal order, left to right and top to bottom.

- *Information affinity*

If more than one anamnestic information is shown, they have to be grouped together and not mixed with heterogeneous information.

- *Consistency of visual organization with causal relationships.*

If there is a link of causality between two pieces of information, the visual organization must allow the user to read the cause first and then the effect. This criterium becomes particularly relevant whenever the user is pursuing a particular strategy.

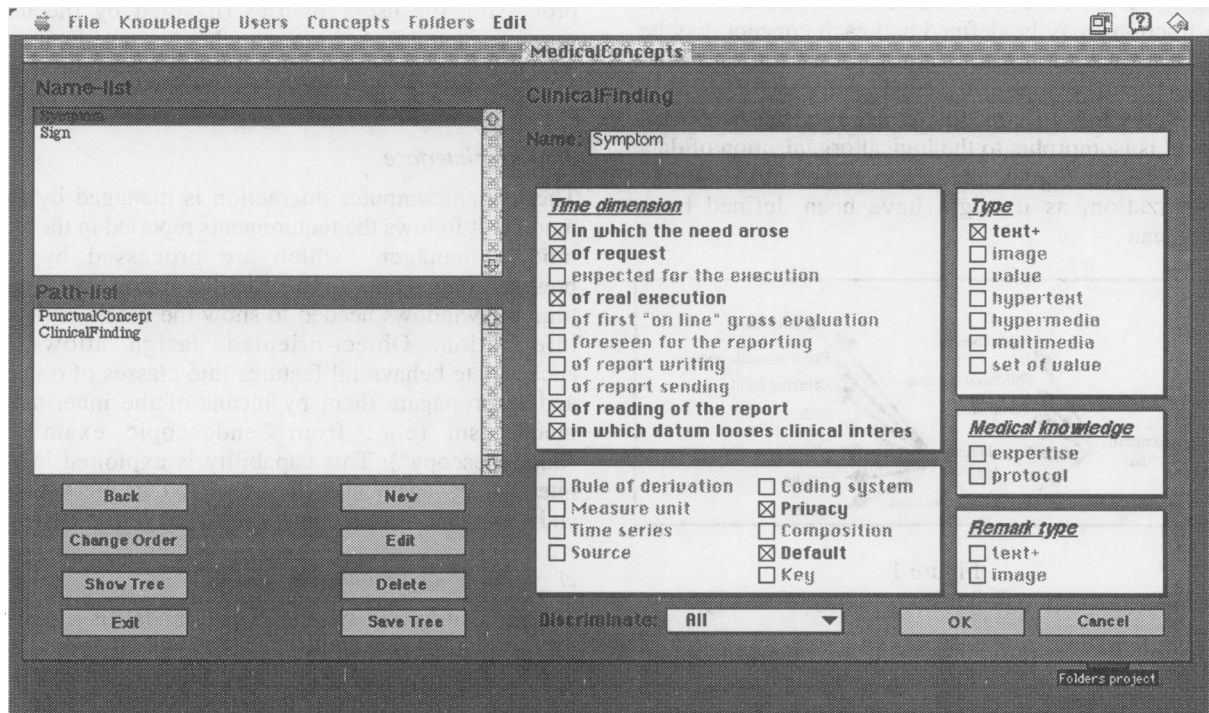


Figure 2
A sample video display output of the patient folder designer.

4. CONCLUSIONS

The ultimate aim of any computerized tool in medicine should be the improvement in the quality of care. This can be achieved also by means of a more effective information management. Its computerization, far from being trivial, is worthwhile only when aimed at improving efficiency in clinical data analysis and ward activity planning. Computerized medical folders can play a significant role by increasing the efficiency in handling clinical information and by supporting daily scheduling of ward activity.

The user must be able to handle images related to one or more patients, to make explicit semantic links with data of different nature, to navigate in a hypertextual

support system, to visualize opportunely the data aggregation results, to query the system, possibly being supported by the system itself. The presentation of the patient folder as a hypermedia document is a convenient method to offer the clinical information to the user in an efficient way.

A patient folder management system should be also the active supporting tool for the creation of the physician's belief about the patient's state of health. It should be able to retrieve and to propose the most appropriate and useful information to the user. Our realization proposes a new philosophy for a patient folder management system, able to tailor the information to the user's belief, goal and knowledge about medical data.

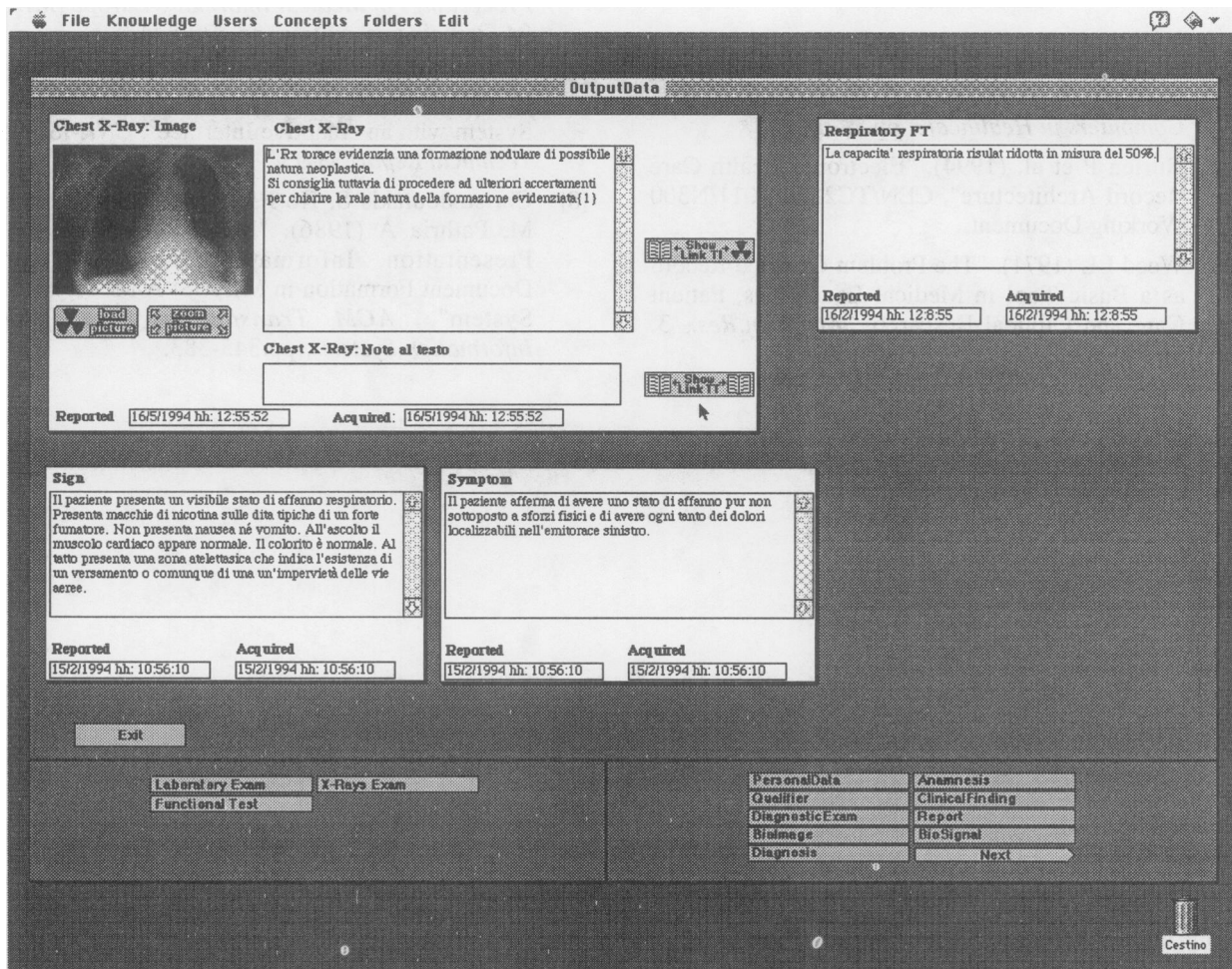


Figure 3
A set of windows semantically related of the multimedia patient folder.

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REFERENCES

- [1] Smith S, Dennis B (1991). "HL7: Facilitating Multiple Approaches to Systems Integration", *Computers in Healthcare*, pp.59-61.
- [2] Hurlen P et al. (1994). "Electronic Health Care Record Architecture", CEN/TC251/PT011/N300 Working Document.
- [3] Weed LL (1971). "The Problem Oriented Record as a Basic Tool in Medical Educations, Patient Care and Clinical Research", *Ann.Clin.Res.*, 3, pp.131-134.
- [4] Acheson HWK (1972). "The Clinical Record as an Aid to Continuing Education in General Practice", *British Journal of Medical Education*, 6, pp.26-35.
- [5] Nowlan WA, Rector AL, Kay S, Goble CA, Horan B, Howkins TJ, Wilson A (1990). "PEN&PAD: A Doctors' Workstation with Intelligent Data Entry and Summaries", in Miller R (ed.) *Proceedings SCAMC 90*, Los Alamitos (CA), IEEE-CS Press, pp. 941-942.
- [6] Ricci FL, Pisanelli DM, Ferri F, Consorti F (1994). "Modeling the Structural and Behavioural Features of Medical Concepts: A Tool for Generating Multimedia Patient Folders", in: Barahona P, Veloso M, Bryant J (eds.) *Proceedings of Medical Informatic Europe (MIE) 94*, Participants' edition, pp.470-474.
- [7] Ferri F, Minarelli Della Valle R, Pisanelli DM, Ricci FL (1993). "A Medical Folder Management System with an Adaptive Interface", *CNR-ISRDS Technical Report* 33-93.
- [8] Christodoulakis S, Ho F, Theodoridou M, Papa M, Pathria A (1986). "Multimedia Document Presentation, Information Extraction and Document Formation in MINOS: A Model and a System", *ACM Transactions on Office Information Systems*, pp.345-383.